NORTON (S.A.)

Edward

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Measures and Weights.

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A LECTURE

ON

Measures and Weights,

DELIVERED OCTOBER 5, 1869,

As Introductory to the Tenth Annual Course of Lectures

In the Miami Medical College of Cincinnati.

By Sidney A. Norton, M. D.,
Professor of Chemistry and Toxicology.

PUBLISHED BY THE CLASS.

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CORRESPONDENCE.

Miami Medical College,
Cincinnati, Oct. 12, 1869.

Prof. S. A. Norton,

Dear Sir:

At a meeting held by the class, J. N. McCormick presiding and R. F. Erdmann acting secretary, the desire to possess a copy of the address delivered by you before the class at the opening of the term, was expressed by many of its members; it was, therefore

Resolved, That a committee, composed of one from each state represented, be appointed to solicit of Prof. Norton, for publication, the manuscript of his address delivered by him before the class of Miami Medical College at the opening exercises of the term of 1869—1870.

J. N. McCormick, *President.*

R. F. Erdmann, *Secretary.*

A. M. Hamilton, Maryland; O. Fuls, Prussia; R. H. Chilton, Kentucky; A. H. Wilson, Minnesota; E. C. Pedan, New York; J. T. Cox, Missouri; T. L. Catherwood, Illinois; S. A. Gillam, Indiana; F. P. Anderson, Ohio, *Committee.*

Mt. Auburn,
October 13, 1869.

Gentlemen:

The address is very cheerfully placed at your disposal. To increase its weight as well as to add to its measure of utility, I have prepared an appendix of tables in strict accordance with the values assigned by Congress.

In full confidence that the members of the class will attain no ordinary standards of worth, and with the best wishes for their advancement in medical science and their future success in practice,

I remain their and your friend and servant,

Sidney A. Norton.

To Messrs. Hamilton, Fuls, and others, *Committee.*

LECTURE.

Ladies and Gentlemen:

In behalf of the Faculty of Miami Medical College, I cordially bid you welcome! They regard your presence here as another token of the kindness which they have ever received from this community. To the sympathy and co-operation of the medical profession and the general public, we owe it that this institution has ceased to be an experiment.

We are grateful that our labors have met with that degree of success which warrants us in making renewed efforts for the future. The teacher is inevitably measured by his pupils. In the credit and confidence which is granted them, in the success which they attain, in the prosperity which crowns their efforts, he shares a part. Hence it is natural that we should regard our graduates as at once our greatest reward and our highest honor. In them, we have already sufficient reasons for gratulation and pride, and we are justified in believing that the future will be as the past and yet more abundant. We are confident that those who are about to enter here to-night on a new term of study, will do the college credit, and merit your esteem and confidence. We bespeak for them your kindness and regard. We ask you to remember that many of them are strangers in a strange land, and that all the conditions by which they are surrounded are such as to give them an especial claim upon your hospitality.

On our part, we are happy to announce that ample provision has been made for an extended course of instruction, both theoretical and practical, and assure you that no pains have been spared to render each department, in the highest degree, efficient, thorough, and comprehensive.

Gentlemen of the Class:

We are about to return from recreation to labor. I trust that you have come here with an earnest purpose to fit yourselves fully for the duties of the profession which you have chosen. No where in this world can great excellence be attained, without great labor. The only

lucky star is perseverance. No accident of birth or fortune can secure a lasting and honorable fame. Although man is said to be the creature of circumstance, the successful man is he who so controls circumstance that he may make it further his own aims. So far will any man be master of his fate as he has learned by excessive pains and enduring toil to comprehend the duties required of him, and to seize every advantage that may be offered. Here we are met for the work of preparation for duties in a specific field. Let it be your care, therefore, to see to it that no diligence be wanting on your part to equip yourselves, well and thoroughly, for every possible emergency.

Let us begin our labors by considering the subject of measures and weights. I have chosen this topic, because I hope to make it of general interest, and because the occasion permits it to be discussed more in detail than would otherwise be advisable.

We can hardly imagine a time when some units of measure were not necessary to express notions of size and distance. Comparisons, drawn as they are now between the length and height of familiar objects and the corresponding dimension of the thing to be described, undoubtedly furnished the first means of measure. The human stature, the arrow's flight, the day's journey, are met with sufficiently often to show how common and how ancient are these means of measurement. So soon, however, as man began to trade and barter, so soon was there a necessity for some generally accepted standard by means of which the exchange could be negotiated. The relation of this standard unit to its multiples and subdivisions would follow next in order, and soon an arbitrary system would be devised which would satisfy all requirements of measure, whether itinerary, maritime, or commercial. The measurement of extension would naturally precede that of weight, and it need not surprise us that the first developed of the sciences was geometry, which, in its primary meaning, signifies the measurement of the earth.

It forms no part of our present purpose to inquire what were the first units of measure used, but judging from those which have come down to our day, it is highly probable that they were derived from human standards. Thus the ancient cubit shows, both by its name, which is cubitum, the elbow, and its length, which varies from sixteen to twenty-five inches, that it was derived from the extreme length of the fore-arm, or from the elbow to the tip of the middle finger. To this day, the Arabs measure cloth by the length of the forearm, but add to its length the width of the other hand, which also serves to mark the limit of each unit. Other similar measures are still in common use; as, the foot, the pace, the finger length, the span, the hand's breadth, or palm, the fathom which

is derived from the orgyia, or the stretch of both arms when extended horizontally. So, also, the seamstress measures the yard by half the orgyia, obtained by stretching a thread from the tips of the fingers to the end of the nose; and, in like manner, the farmer finds a convenient measure of the foot in the space included between both palms and the outstretched thumbs. Inaccurate as these units are as applied to any individual, one learns almost insensibly so to adapt his natural means of measurement that they will sensibly coincide with the average length, or with the accepted standard.

As natural units of volume, we have the handfull, the pugillus, or grasp of the thumb and two fingers, and the pinch. Probably the earliest measures of capacity were derived from shells, or other hollow objects; but of this we know but little.

I know of no natural unit of weight, if the record of Diedrich Knickerbocker be untrustworthy. He states that the Dutch traders of the Nieuw Nederlandts established as "invariable table of avoirdupois, that the hand of a Dutchman weighed one pound and his foot two pounds," and adds that if a bundle of furs, never so large, were placed in one scale and "a Dutchman put his hand or foot in the other, the bundle was sure to kick the beam—never was a package of furs known to weigh more than two pounds in the market of Communipaw." Leaving this as somewhat fanciful, we have some trace of early European weights in the arbitrary stone. This measure is far from constant, varying not merely with the nation but also with the different trades or guilds.

One thing is generally noticeable in the dimensions assigned to these different natural units of length, namely, that the standard is in excess of the ordinary length of the thing designated. Thus the natural foot in a large-sized man seldom much exceeds ten inches; but the standard foot in all civilized nations, is never less than eleven inches, and, in some cases, it exceeds fourteen inches. The Roman pace was really a stride five feet long, and a thousand of these, or *mille passuum*, was a mile only a little shorter than our mile. The span varies from nine to nearly eleven inches, but that is a large space to be included between the middle finger and the thumb; and so also that hand's breadth is large which measures the four inches, or hand, still used in speaking of the height of horses. From these facts, it is natural to conclude that the actual standard finally assumed was from some man above the normal size; in all probability from some chieftain like king Saul, who "when he stood among the people, was higher than any of the people from his shoulders and upward."

Nevertheless, it will be readily seen that measures thus derived

would vary, from time to time, unless some arbitrary unit were fixed by law. The actual magnitude of the unit, is a matter of very little importance, but any nation will become so accustomed to its own standard, and find so many ways of adapting its multiples and subdivisions to the affairs of life, that its own unit will seem to its people as the only convenient measure possible. For this reason any change in the standard is sure to meet with opposition, especially if the new measure is called by an unfamiliar name. When intercourse between different nations was limited, no inconvenience was felt if every little principality had its own local standards. But now that commerce has spread her sails in every sea, and opened her markets throughout the world, there is a necessity that the great household of the globe should employ a common standard in everything pertaining to measure, whether it relate to extension, to weight, to time, or to money. This desirable result may be attained at some future day, but now there are many obstacles which hinder and prevent the adoption of a common standard. The difficulty of making the change is magnified ; the popular ignorance in relation to standards of any sort, the indifference of those who do not personally feel the necessity or even the advantage of a common system of measures, the proverbial immutability of habit, all combine in conserving whatever methods are in common and habitual use. But by far the most serious hindrance is found in the jealousy existing between different nations and especially among those who claim to be among the great powers. The assumptions of England, in this respect, are so marked as to be almost ludicrous. So long as she maintains her undoubted superiority in commerce, so long she will insist that if any change be made it shall be that other nations shall conform to her standards.

As the United States has no standard, purely local, and has legalized both those of England and of France, we may be considered as utterly unbiased on the question of the relative worth of any standards. If, with the experience of the past, all existing measures could be abolished and an entirely new system established, no doubt it would be easy to devise a better system than anywhere exists at the present, for reasons which will soon appear.

If, then, we were to form a new standard, the first thing to be determined is the unit. The requisites absolutely essential in the unit are, that it should be convenient, invariable, and easily reproduced if lost. The most convenient units are those derived from human standards, or from easily accessible natural objects. But these are exposed to the vicissitudes of time and are never invariable ; besides, there is a difficulty in determining what particular objects shall be assumed as in exact con-

formity with the definition of the unit. Thus, when the inch was defined as the length of three rounded barley corns, placed end to end, a dispute arose as to how much the grains should be rounded; so also the pennyweight was first defined to be equal to the weight of thirty-two and afterward twenty-four grains of wheat taken from the centre of the ear and well dried; thus, two sources of error were introduced to enhance the difficulty of reproducing the standard.

The absolute constants or invariable units in nature are very few, and no one has yet been determined with such positive certainty that we may claim to have measured it with perfect accuracy. Among the available natural constants, from which we might hope to reproduce the standard if lost, are, (1.) the polar diameter of the earth; (2.) the length of a given meridian; (3.) the effect produced by the force of gravity on a body free to move in vacuo in a given time, as one second. This last furnishes two units, (1.) the space through which a body falls in the first second, or (2.) the length of a pendulum which vibrates in one second.

Either of the last two involves the idea of time, but, fortunately, a day is a natural and invariable unit of time, since the period of the revolution of the earth on its axis has not been known to vary in the least for two thousand years. Hence, any aliquot part of the day, as a second, furnishes a convenient unit of time. This unit of time is convertible into a unit of length by the length of a pendulum which beats seconds in vacuo. Thus, if we can determine the length of this simple pendulum and the time of its vibration, we may readily estimate the length of a seconds pendulum by a well known mathematical formula. Every compound pendulum, like this uniform rod, has in it two points, the one called the centre of suspension, the other, which is always below the centre of gravity, is called the centre of oscillation, because all the matter of the rod may be considered as situated in it. These two points are so related that, if the pendulum be suspended at either centre, it will vibrate in the same time, as this simple experiment will show. Hence, the actual length of the pendulum, not of the rod, is the distance between these two centres. From this it would appear that the seconds pendulum combines all the requisite essentials for a standard of length. For these reasons it was ordered by an act of the English Parliament, passed in 1824, that if, at any time, the Imperial standard yard should be destroyed, it should be restored by a "new standard yard, bearing the proportion to a pendulum vibrating seconds of mean time in the latitude of London in a vacuum and at the level of the sea, as 36 inches is to 39.1393 inches." Nothing could be more simple, unless it be to make the inch an aliquot part of the length of the pendulum; but when the

yard was destroyed by the fire in 1834, which consumed both Houses of Parliament, it was found that in order to restore the lost yard in the manner prescribed, so many precautions were necessary that the standard yard could not be restored by means of a pendulum to within $\frac{1}{500}$ of an inch, or $\frac{1}{18000}$ of its whole length. This difference, although it would be disregarded in ordinary commercial transactions, is a large error in a standard which assumes to be scientific. When the act was revised in 1855, no mention whatever was made of the proportion between the yard and the seconds pendulum; so that the present standard Imperial yard is entirely arbitrary.

Another difficulty in reproducing the standard from the seconds pendulum in any place and time, which would be necessary to render the standard universal, arises from the fact that the force of gravity diminishes with the altitude of the station above the level of the sea, diminishes as the station is removed from the pole toward the equator, and is besides subject to local variation in stations on the same parallel of latitude. For these reasons, it is not likely that the seconds pendulum will again be used as the basis of any unit of length.

The French sought to obtain a standard from the length of a meridian, or a north and south line extending on the surface of the globe from pole to pole. The assembly, in 1790, appointed a committee from the French Academy, who proposed in their report of the following year that the basis of the new metrical system should be "the ten millionth part of the quadrant of the globe," and be called a *metre*. They also proposed that all measures should be derived from this in an ascending and descending scale of ten, or on the decimal system. This report was adopted, and a north and south line of 650 miles, extending from Dunkirk to Barcelona, was measured with every precaution that scientific skill of the highest order could suggest, in order to compute the distance from the equator to the pole. The result of this survey was that the metre was established with considerable accuracy as equal to 39.37079 English, or 39.3685 inches of the United States coast survey. Unfortunately, after this standard had been legalized, and authenticated copies had been distributed throughout the departments, it was found that three errors had been made in the computations which partially neutralized each other. From these errors it resulted, that the legalized metre was shorter by $\frac{1}{5590}$ part of its length than the metre as defined by the academy. It was, however, thought inadvisable to make the correction, and, consequently, the French standard metre of platinum is as arbitrary a standard as the English yard. A comparison of more extended and recent surveys shows that had the metre been corrected when the errors

were first discovered, it would still have been inaccurate to an appreciable amount. Moreover, these recent surveys have determined that the equator is by no means an exact circle, and consequently that the meridians will differ somewhat from each other. This vitiates the claim of any meridian to be the universal standard.

There then remains the only available unit in the polar diameter of the globe. This is found to be very nearly 500,500,000 inches; and Sir John Herschel proposes that the $\frac{1}{500000000}$ part of this be made the standard English inch. This would merely increase the length of the inch by its thousandth part, which would be of no moment in commercial transactions, and of but little advantage in any light beyond that of pleasing the fancy in having a scientific definition of an inch.

As one of the curiosities of this subject I will add a defense of the English inch as solemnly propounded by the astronomer royal of Scotland. He has been making measurements in the pyramid of Cheops, and has there found what he calls "Our Inheritance in the Great Pyramid." According to his notions, the secret of the pyramid lies in the fact that it was the embodiment of all sorts of measures. The queen's chamber is built to typify the sabbatical week. The base of the pyramid commemorates the length of the year. The proportions of the pyramid reveal the geometrical value *pi* or the relation of the circumference to the diameter of a circle, and in its general dimensions, the consecrated unit of measure is preserved. For if you will allow that the sacred cubit is twenty-five inches, he asserts that we shall find it "remarkably and astonishingly earth-commensurable, being the $\frac{1}{10000000}$ of the semi-axis of rotation of the earth." Further, he declares that because a granite chest in the king's chamber is twice as large outside as inside, and is contained fifty times in the space enclosed by the lowest tier of stones of the chamber, this chest must have been used as a standard of measure, and hints that this was also one purpose of the ark of the covenant. Then, the coffer contains 71,317 cubic inches; now the cube of 25 is contained about 5.7 times in this number, and 5.7 is one value assigned for the density of the earth, and hence the pyramid builders knew the specific gravity of the earth. Finally, since the English inch is only $\frac{1}{1000}$ part less than the value he assigns to the pyramidal inch, he deduces the remarkable conclusion that the English inch is almost, if not quite, the result of divine inspiration. He also seems of the opinion that the French measures are atheistical, and oppressive to the poor. Surely imagination, *non sequiturs*, and assumption can go no further.

In point of fact, all existing standards are alike arbitrary, and it is hardly worth the while to make any further attempts to find a natural

and invariable one. All that is needed, is that some one standard should be selected as on the whole the most convenient, and that exact copies of this, duly authenticated, should be distributed as the necessities of commerce and exchange require. They should be made of indestructible material, and preserved from injury by all needed precautions. Platinum, bronze, or brass, are well fitted for such purposes.

Here another precaution is necessary. All bodies expand by heat and contract by cold. Thus this little brass ball will now pass freely through this ring; but if I heat it for a little while, it expands so much that it becomes too large to pass. So, too, if you place a kettle even full of cold water on the stove, the water will run over long before it is hot enough to boil. The pyrometer will better show the same fact. Thus when I apply heat to this rod you see that it almost immediately drives the index along the scale, showing an easily measurable increase in the length of the rod. When I withdraw the heat, the rod again contracts and the index falls. Hence it is necessary to define at what temperature the scale shall be the standard. Now the temperature to be selected, or the normal temperature, is merely a matter of choice. The English speaking people have very generally assumed the temperature of 62° Fah. as the normal to which all weights and measures shall be referred. In France, all tables of weights are referred to the temperature of water at its maximum density, which is 39°.2 Fah.; but their metre is a standard at 32° Fah. or 0° C., which is the temperature of freezing water or of melting ice. Since this last temperature is invariable under the same circumstances of pressure and adhesion, and is easy to obtain, it seems that it should be generally assumed as the normal. Even in France, the determination of the specific gravity of solids and liquids is made with the water of melting ice, though it is afterward referred to that of water at its maximum density.

Since the normals assumed by different nations vary, it follows that the temperature should be taken into account when the standards are compared; that is to say, the French standard platinum metre at 32° Fah. is equal to 39.3709 inches of the English bronze yard at 62° Fah.; but this would not be the case if the two standards were compared at any common temperature.

Now as to the subdivisions of the unit, the question is not so one-sided as some have been led to suppose. For scientific purposes, the decimal system is without doubt the best, as all other measures are generally reduced to decimals in extended calculations. For the common affairs of life a system which will give fractional parts of a larger unit in whole numbers of a smaller is the most convenient. Thus the apothe-

caries' or troy ounce of 480 grains is much more convenient than the avoirdupois ounce of 437.5 grains, because many aliquot parts may be obtained from it in whole numbers of grains. There would be an advantage gained in having all the scales rise by multiples of the same number; but this is only done in the decimal scale, which rises by tens, and the duodecimal, which rises by twelves. For my part, I am free to confess a partiality for the duodecimal system, because so many aliquot parts may be obtained from it. Thus $\frac{1}{12}$ $\frac{1}{6}$ $\frac{1}{4}$ $\frac{1}{3}$ or $\frac{1}{2}$ a foot is an exact number of inches; but if the foot were divided into ten inches, the only aliquot parts are $\frac{1}{10}$ $\frac{1}{5}$ and $\frac{1}{2}$. If the duodecimal system had been extended through all our weights, measures, and coins, its convenience would have been so apparent that it is highly probable no change would have been desired. It is, however, clear that the decimal system would be a great advantage to us if it could supplant our exceedingly diverse and complex system of weights and measures.

This system is generally used in France for all values except those of time and angles. The committee of the academy proposed to decimalize these also, but they soon fell into disuse. The quadrant was to contain 100 degrees, each degree 100 minutes, and each minute 100 seconds. I see no reason why this was given up, unless it be that the new tables of circular functions could not, at once, be procured for mathematical calculations. The second of time is entirely arbitrary, and might as well be the $\frac{1}{100000}$ part of a day as the $\frac{1}{86400}$ part; so, too, the day might as well consist of 10 hours of 100 minutes each, as of any other value; but here the change was impracticable, because of the expense required tc change all the clocks and watches of the empire. I have nothing to offer in favor of a week of 10 days.

There is one other consideration of no little importance, which is the relation which the units of extension and weight bear to each other. Whatever be the unit of length, the unit of capacity should be its exact cube. We have cubic feet and cubic yards, but our gallons, bushels, and the like, bear no simple relation to the cubic inch. So also the units of weight should rise naturally from those of volume, or be capable of derivation from the weight of a given cube of distilled water at the normal temperature. Thus we say, "A pint's a pound the world around." The cubic inch contains of distilled water at 62° Fah., weighed in vacuo, 252.722 grains, and in air 252.456 grains. The cubic foot contains 997.45 ounces. Thus with a very little variation in the inch, the cubic foot might readily be made the unit of capacity, and also of weight as containing a thousand ounces. This consideration, and not the decimal system, is the great advantage of the French metrical system. In it, the

figures which represent the specific gravity of any substance also represent the weight in terms of the given unit, consequently the bulk and weight of a body are readily deducible, one from the other.

On the whole, then, from purely theoretical considerations, the French system of weights and measures is the most perfect and convenient known, and its superiority over the English will be more apparent by comparing the practical working of the two systems now in detail. Our standards in common use are English; but by an act of congress, authorized July 28, 1866, the French system is also legalized in this country. It therefore behooves us to master both; but it is to be hoped that the decimal system will soon come into general use.

The English system dates its origin from after the time of the Conqueror. Henry the First of England is said to have ordered that the ulna, or ancient ell, which corresponds to the modern yard, should be made of the exact length of his own arm, and that all other measures of length should be based upon it. This standard has been perpetuated by several successive enactments, and is now, in theory, the identical yard used in the United States and in Great Britain. The several copies made from this varied more or less by reason of inaccurate adjustment, until, finally, it was necessary to legalize a certain scale, made by Bird, as the standard. This was done by an act of parliament passed in June, 1824, which declares that "from and after the first day of January, 1826, the straight line, or the distance between the centres of the two points in the gold studs in the straight brass rod now in the custody of the clerk of the house of commons, whereon the words and figures, 'Standard yard, 1760,' are engraved, shall be the original and genuine standard of length or lineal extension called a yard, and the same straight line, or distance between the centres of the said two points in the said gold studs in the said brass rod, the brass being at the temperature of 62° by Fahrenheit's thermometer, shall be and is hereby denominated the 'Imperial yard,' and shall be and is hereby declared to be the unit and only standard measure of extension wherefrom or whereby all other measures of extension whatsoever, whether the same be lineal, superficial, or solid, shall be derived, computed, and ascertained; and that all measures of length shall be taken in parts, or multiples, or certain proportions of the said standard yard; and that one-third part of the said standard yard shall be a foot, and the twelfth part of such foot shall be an inch."

Nevertheless, when it was sought to reproduce exact copies of this standard, it was found that the points in the centres of the gold studs had an appreciable diameter, that they were not round, and that their centres were not easily ascertained. Hence the several copies somewhat vary.

The actual standard of length of the United States is a brass scale 82 inches long, prepared for the coast survey by Troughton, of London, in 1813. The temperature at which this scale is a standard is 62° Fah., and the yard measure is between the 27th and 63d inches of this scale. When the parliamentary standard was destroyed it was restored from the best authenticated copies which then existed, and was legalized in 1855. Bronze copies were then prepared with the most painstaking accuracy and distributed throughout the realm. By a comparison of the bronze standard with the Troughton scale of the coast survey, it was found that the British yard is shorter than the American by about $\frac{1}{40000}$ of its length. This quantity is by no means inappreciable, since science claims to measure the $\frac{1}{200000}$ part of an inch.

It is to be regretted that the units of capacity are not related to those of length by some simple multiple; but at the time the standard of length was defined, several gallons of different capacities were in common use, and a sort of compromise was made between them. The Imperial gallon which was substituted for all arbitrary measures of volume in Great Britain has a capacity of 277.274 cubic inches. It contains 1.2 wine gallons.

No such change has been made in the United States. Our standard of liquid measure is the wine gallon of 231 cubic inches. Our standard of dry measure is the gallon derived from the Winchester bushel, and contains 268.8 cubic inches.

Our only unit of weight is the grain which was originally a sound and full kernel of wheat well dried. A troy pound contains 5,760 grains, and an avoirdupois pound contains 7,000 grains. The Imperial gallon contains exactly 10 avoirdupois pounds of distilled water at the temperature of 62° Fah. This is now the Imperial standard pound of England, and the only one whose ounce of 437.5 grains has a legal existence Its pint is exactly a pound and a quarter of pure water. The standard of weight in the United States is the troy pound, from which is derived the avoirdupois pound. The troy and apothecaries' pound are identical in value, and are also identical in the ounce, which is 480 grains, and in the grain.

There is no simple relation between the wine gallon of the apothecaries' measure and the troy pound.

The wine gallon which is subdivided into 61,440 minims, contains 58,333.31 grains, so that a minim is a little less than one grain. As these, the smallest denominations of each table, are unequal, the inequality will increase with their multiples. As you are aware, in the apothecaries' measure :

60 minims (♏)	make	one drachm.	(f℈)
8 drachms	"	one ounce.	(f℥)
16 ounces	"	one pint.	(o)
8 pints	"	one gallon.	(cong.)

In the apothecaries' weight :

20 grains (gr.)	make	one scruple.	(℈)
3 scruples	"	one drachm.	(ʒ)
8 drachms	"	one ounce.	(℥)
12 ounces	"	one pound.	(lb)

Now, although some of the terms are alike, the denominations of the two tables never agree ; thus the fluid-drachm is 56.96 grains, the solid or troy drachm is 60 grains ; the fluid-ounce is 24.28 grains less than the troy ounce, and the pint contains 1.266 troy, or 1.0416 avoirdupois pounds of distilled water. The two tables, therefore, should be carefully distinguished, and where ambiguity is possible in writing prescriptions the signs which represent the fluid measures, should be prefixed with the initial f.

Before leaving this topic, it is well to notice that the minim is not the exact equivalent of the drop. In many cases, as in aqua ammonia, they are sufficiently near for practical purposes ; but in others, the drop will vary considerably from the minim. Thus in a single drachm of 60 minims there may be 45 drops of water, 90 drops of sulphuric acid, 120 drops of the essential oils, 150 drops of ether, and even 200 drops of chloroform. Then again, the size of the drop varies with the circumstances under which it is formed, as the size and shape of the mouth of the vessel containing the liquid, the temperature, and so on.

In 1863, the British General Medical Council resolved to make the apothecaries' pound consist of 20 fluid-ounces, each equal to the avoirdupois ounce of 437.5 grains, instead of 480 grains. Hence the present British minim and fluid-drachms are about $\frac{1}{11}$ less than ours.

In general prescriptions, a tea-spoon may be reckoned as about one fluid-drachm, a table spoon about one-half a fluid-ounce ; a wine glass from $1\frac{1}{2}$ to 2 ounces, and a glass or cup full from 4 to 5 ounces, although these values vary with the caprice of the manufacturer.

As we have seen, the French unit of linear measure is the metre and all other values are derived from that in multiples and subdivisions by tens. Whatever be the name of the unit, the subdivisions have the Latin prefixes deci ($\frac{1}{10}$), centi ($\frac{1}{100}$), milli ($\frac{1}{1000}$),—its multiples, the Greek prefixes deca (10), hecto (100), and kilo (1000). Thus the descending scale of length is the metre, decimetre, centimetre, milli-

metre ; the ascending scale, the metre, decametre, hectometre, kilometre, and so similarly for the other tables.

The are is 100 square metres, and the stere is one cubic metre. These are used for measuring surfaces and solid bodies.

The French standard of liquid measure is the litre, which is the cubic decimetre. The litre should therefore contain 61.02705 cubic inches, which is 2.1135 wine pints. As adopted by the United States, it is defined to contain 61.022 cubic inches.

The French unit of weight is the weight of a cubic centimetre of water at its maximum density (39°. 2 Fah.) and is called a gramme. By this definition the gramme should equal 15.44242 grains, but from an inaccuracy in constructing the standard cubic centimetre the actual gramme in use is 15.43235 grains. In ordinary commercial transactions the kilogramme, which corresponds to 2.2 lbs. avoirdupois is used.

No confusion can arise from the use of these various denominations in any proportion, any more than from the use of our dollars, dimes, cents, and mills. The value of each denomination is clearly seen by its position with regard to the decimal point. They are easily convertible into the common denominations, but if they were once in general use, no one would think of converting a metre into feet, or a litre into pints, or a gramme into grains. In making any relative calculation, as the per centum of each element in a chemical analysis, the value of the unit is of no importance so long as the subdivisions and multiples are made with perfect accuracy. The decimal system is found so convenient in scientific researches that, where the result must be given in English units, the weights for the balance are made in 1 ; 10; 100; 1000 troy grains without reference to the ounce or pound.

The French system has been generally adopted on the continent of Europe and seems destined to become general, if not universal. At present, the different systems in use iu onr scientific treaties are so perplexing, from the constant reductions required, that it is to be fervently hoped that the annoyance will find a speedy end.

With this system should go the centigrade thermometer, which divides the temperature between the freezing and boiling points of water into 100 degrees.

With so much to commend it, and so many good reasons for adopting the decimal metrical system as the common standard for all civilized nations, it is really remarkable that it has been in use for three-quarters of a century and not fully adopted, as yet, even in France. The only step toward popularizing the system in this country is in our new five cent pieces, which weigh 5 grammes, and are about 2 centimetres in

diameter, and in the weight of a letter which is permitted to be 15 grammes, or a little more than half an ounce. We may rest assured that the system will not be adopted unless it is made compulsory, although the general sentiment of scholars is in favor of the change.

And now, gentlemen, you will not think that I am dealing in trivial conceits if I remind you that there are other measures than those which relate to traffic and barter. The measure of a MAN is not expressed by inches, or pounds, or pence. You measure others and are measured yourselves as *men*. The honest, earnest, upright, kind-hearted man is the unit of life. You know how clearly and accurately defined is the standard which marks the perfect man, and you know that but one such standard has ever trod this earth. We may not equal this perfect standard, too many imperfections crowd our earthly natures, but we may strive and pray that some day we shall be like Him.

The fictitious honors of the knave, the transient pleasures of the fool, are but iridescent bubbles that distract for a moment our attention from computing the worth of their possessors. Sooner or later the bubbles break, and then their former owners are surely tried both with plummet and with balance.

Bear in mind how noble is an honest man. Honest, I mean, not merely in a paltry, pitiful dicker, but honest in aspiration, honest in thought, honest in word, honest in deed. Honest, not merely to his fellow man, but also honest to himself, and, above all, honest to his God. Such a man is the honorable man. If the sweetest word on earth is Home, the most inspiring word is Honor. Let these words be your talismans and they will shield you from dangers and temptations that you know not of. With so many inducements to forget oneself for a time, it is not easy always to remember our highest purpose in life. Erring and self-deceived though all of us often are, let us all, teachers and students strive, so to live, and work, and love, that, at the last, when we are weighed in the balance, we shall not be found wanting.

UNITED STATES MEASURES AND WEIGHTS.

I. MEASURES OF LENGTH.

Mile.	Furlongs.	Rods.	Yards.	Feet.	Inches.	Metres.
1	8	320	1760	5280	63360	1609.3472
	1	40	220	660	7920	201.1684
		1	5.5	16.5	198	5.0292
			1	3	36	0.9144
				1	12	0.3048
					1	0.0254
.000621	.00497	.1988	1.0936	3.2807	39.3685	1.

II. DRY MEASURE.

Bushel.	Gallons.	Quarts.	Pints.	Cubic Inches.	Grains of Water.	Litres.
1	8	32	64	2150.42	542890.73	35.24007
	1	4	8	268.8	67861.34	4.40501
		1	2	67.2	16965.33	1.10123
			1	33.6	8487.66	0.5506
				1	252.46	0.0164
.028	.227	.908	1.816	61.022	15432.35	1.

III. APOTHECARIES' MEASURE.

Gallon.	Pints.	Ounces.	Drachms.	Minims.	Grs. Water.	Cubic Inches.	Litres.
1	8	128	1024	61440	58333.31	231.	3.7854
	O.1	16	128	7680	7291.66	28.875	0.4732
		fl.℥1	8	480	455.72	1.8047	0.0296
			fl.ʒ 1	60	56.96	0.2256	0.0037
				♏ 1	0.95	0.0038	0.0006
0.26417	2.113	33.82	270.54	16232	15432.35	61.022	1.

IV. AVOIRDUPOIS WEIGHT.

Pound.	Ounces.	Drachms.	Grains.	Cub. Inch. Water.	Grammes.
1	16	256	7000	27.7274	453.6028
	1	16	437.5	1.733	28.3502
		1	27.34	0.103	1.772
			1.	0.004	0.0648
.0022	.03527	0.964	15.43235	0.061	1.

V. APOTHECARIES' TROY WEIGHT.

Pound.	Ounces.	Drachms.	Scruples.	Grains.	Cub. In. Water.	Grammes.
1	12	96	288	5760	22.8157	373.25
	℥ 1	8	24	480	1.9014	31.104
		ʒ 1	3	60	0.2377	3.888
			℈ 1	20	0.0792	1.296
				1.	0.004	0.0648
.002679	.032	0.257	0.7716	15.432	0.061	1.

VI. BRITISH OR IMPERIAL MEASURE.

Bushel.	Gallons.	Quarts.	Pints.	Cub. Inches.	Grs. Water.	Av'pois Lbs.	Litres.
1	8	32	64	2218.192	.560,000.	80	36.348
	1	4	8	277.274	70,000.	10	4.543
		1	2	69.318	17,500.	2.5	1.136
			1	34.659	8,750.	1.25	0.568
0.0275	0.22017	0.88066	1.7613	61.027	15442.42	2.206	1.

VII. RELATION OF UNITS OF VOLUME.

Imperial Pints.	Dry Pints.	Apothecaries' Pints.	French Litres.
1.	1.031	1.203	0.5679
.9694	1.	1.163	0.5506
.8331	0.8593	1.	0.4731
1.7613	1.816	2.113	1.

VIII. RELATION OF UNITS OF WEIGHT.

AVOIRDUPOIS.		TROY.		APOTHECARIES.		FRENCH.	
Pound.	Ounce.	Pound.	Ounce.	Pint.	Ounce.	Kilogramme	Gramme.
1.	16.	1.2135	14.56	.96	15.36	.4536	453.6028
.0625	1.	.0758	.909	.06	.96	.0283	28.35
.8228	13.16	.1	12.	.791	12.63	.37325	373.25
.0685	1.097	.0833	1.	.066	1.056	.0311	31.10
1.0416	16.666	1.265	15.3	1.	16.	.4731	473.1
.0651	1.0416	.0791	.949	.0625	1.	.0295	29.5
2.204	35.27	2.679	32.15	2.1163	33.86	1.	1000.
.002	.035	.0026	.032	.0021	.034	.001	1.

FRENCH MEASURES ADOPTED BY CONGRESS IN 1866.

IX. MEASURE OF LENGTH.

	Values in Metres.	Equivalents in use.
Myriametre	10000.	6.2137 miles.
Kilometre	1000.	.62137 "
Hectometre	100.	19.88 rods.
Decametre	10.	32.807 feet.
Metre	1.	3.2807 " or 39.3685 inches.
Decimetre	.1	3.9368 inches.
Centimetre	.01	.3936 "
Millimetre	.001	.0394 "

X. MEASURES OF VOLUME.

	Values in Litres.	Cubic Measure.	Equivalents in use. Wine Measure.	Dry Measure.
Stere	1000.	1 cubic metre.	1.308 cubic yds.	264.17 gallons.
Hectolitre	100.	1-10 " "	2.837 bushels.	26.417 "
Decalitre	10.	10 " decimetres.	9.08 quarts.	10.564 quarts.
Litre	1.	1 " "	1.816 pints.	2.113 pints.
Decilitre	.1	1-10 " "	0.73 gills.	3.38 fl. ℥.
Centilitre	.01	10 " centimetres.	.61 cub. inch.	2.7 fl. ʒ.
Millilitre	.001	1 " "	.061 " "	16.2 ♏.

XI. WEIGHTS.

	Values in Grammes.	Equivalents in use. Av'dupois Weight.	Troy Weight.
Millier or Tonneau	1000000.	2204.6 lbs.	2679.22 lbs.
Quintal	100000.	220.46 "	267.922 "
Myriagramme	10000.	22.046 "	26.7922 "
Kilogramme	1000.	2.2046 "	2.67922 "
Hectogramme	100.	3.5274 oz.	3.215 oz.
Decagramme	10.	.3527 "	2.572 drms.
Gramme	1.	15.43235	about 1-4 drm.
Decigramme	.1	1.54323	1.54 grs.
Centigramme	.01	.15432	about 1-6 gr.
Milligramme	.001	.0154	about 1-65 "